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Fast-rotating nearby solar-type stars⋆,⋆⋆

I. Spectral classification, $v \sin i$, Li abundances and X-ray luminosities

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Abstract. We present the results of high-resolution spectroscopic and high-precision photometric observations on a sample of 129 late-F and G-type nearby stars selected on the basis of their large rotational velocity. Using also data from the Hipparcos satellite, CORAVEL and from the ROSAT satellite database, we infer spectral types, compute radial velocities, $v \sin i$, Li abundances and X-ray luminosities and investigate the single or binary nature of the sample stars. Such a careful analysis of our sample shows a large fraction of binaries (≃62%) and of young single disk stars. In particular, at least 9 stars can be considered bona-fide PMS or ZAMS objects, and 30 stars are identified as SBs for the first time. Information on the presence of Ca II K emission and on optical variability is given for some of the stars of the sample.

Key words. stars: abundances – stars: activity – stars: fundamental parameters – stars: variables: general – X-rays: stars

1. Introduction

A detailed investigation of the properties of young stars is certainly relevant for our understanding of the evolution of pre-main sequence (PMS) stars and of the dynamical and chemical evolution of the Galaxy. Classical T Tauri stars are characterized by extreme properties such as IR excess or strong Hα emission; they can be therefore identified using low resolution spectroscopic observations coupled with IR surveys (Gregorio-Hetem et al. 1992; Torres et al. 1995; Torres 1998). On the contrary, stars which are either in the post-T Tauri (PTTS) phase or have just arrived on the main sequence (ZAMS) are difficult to select, because they lack these strong signatures. Due to these difficulties few PTTS and ZAMS stars have been studied in the solar neighborhood, despite the fact that they are in a very crucial phase of evolution. Some candidates have been recentely found through large surveys of stellar X-ray sources (Favata et al. 1993; Tagliaferri et al. 1994; Micela et al. 1997; Cutispoto et al. 1999, 2000; Neuhäuser et al. 2000; Torres et al. 2000), or by studying close binaries and searching among late-type companions of early-type stars (Lindroos 1985, 1986; Pallavicini et al. 1992). The most interesting result of these studies is that there seems to be an excess of young stars, near ZAMS or even younger, compared to what is predicted by Galaxy models.

The determination of stellar age is a rather difficult task for G-type dwarfs. According to Skumanich (1972) the most relevant signatures of youth are: high stellar rotational velocity ($v \sin i$), high lithium abundance and high

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⋆ Based on data collected at the European Southern Observatory, La Silla, Chile.

⋆⋆ Tables 1, 3, 4 and 5 and the complete data set are only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via
http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/384/491

cromospheric/coronal activity. In this context the age vs. $v\sin i$, lithium abundance ($A_{\rm Li}$) and activity relations have a very simple interpretation: all these quantities decrease with stellar age.

This paradigm, although some aspects remain intact after almost 30 years (i.e. stars with $A_{\rm Li}\simeq 3.3$, high $L_{\rm X}/L_{\rm bol}$ and high $v\sin i$ have been shown to be younger than young clusters as the Pleiades and in some cases to be PMS or PTT stars), has turned out to be much more complex than originally thought. For instance, the high activity shown by the RS CVn-type binaries, which are old evolved systems, has indicated that the parameter governing stellar activity is indeed the rotational velocity, and that, therefore, short period binary systems may have a high level of coronal and chromospheric emission despite their old age (Belloni et al. 1993; Fleming & Tagliaferri 1996; Belloni & Tagliaferri 1997; Ottmann et al. 1997). The connection between age and $A_{\rm Li}$ is even more difficult to understand. For G-type stars values of $A_{\rm Li}\sim 2.4$–2.7 can be found for objects spanning 3–4 Gyrs, as the Hyades and M 67 (Pasquini et al. 1994, 1997), although no old single star is known, so far, to have very high $A_{\rm Li}$. The literature on the above subjects is really enourmous, and it includes a number of detailed studies of $A_{\rm Li}$, rotation and X-ray luminosity in young open clusters (see among others, Randich et al. 1998, 2000; Jeffries & Tolley 1998; Ford et al. 2001; Briggs et al. 2000).

For all these reasons we believe that it would be extremely interesting to observe a sample which, instead of being selected on the basis of high activity or young age, is selected on the basis of high rotational velocity. We would expect that such a sample is composed, without exception, by stars with high coronal activity. It should include young single (or binary) stars, as well as short period older binaries, the former with a very high $A_{\rm Li}$ (i.e. higher than the Hyades), the latter with a large spread in $A_{\rm Li}$. In any case, the average $A_{\rm Li}$ should be higher than what is expected in field stars of the same spectral type, selected only on the basis of their distance to the Sun. Finally, we stress that we would not expect either low activity stars or single stars with low $A_{\rm Li}$.

In this paper we present our data analysis and infer for most of the stars in the sample accurate spectral classification, $v\sin i$, $A_{\rm Li}$, radial velocity and X-ray luminosity. A comparison of the $A_{\rm Li}$ of the stars of our sample with that of the Pleiades and Hyades clusters, the relationships between $v\sin i$, $A_{\rm Li}$, and X-ray luminosity and the global properties of our sample will be discussed in detail by Cutispoto et al. (2002), hereafter referred to as PAP II.

2. Data sample and observations

2.1. The sample

We have selected our sample from a CORAVEL survey of 3200 late-F to G-type stars brighter than $V\simeq 8.6$. The main list of F8-G0 dwarf was defined from the *ubvy* photometric survey of Olsen (1983, 1993) as part of a comprehensive inventory of the nearby F and G dwarf as described by Nordström et al. (1996).

Within this photometrically defined sample, the only criterion used to select candidate stars for the present study was a fairly high rotational velocity as measured from the width of the CORAVEL cross-correlation profile (Baranne et al. 1979). Specifically, a lower limit of 8 km s^{-1} was chosen for the σ of the Gaussian fit to the profile (in the system of the southern CORAVEL); with an average σ in *"non-rotating"* stars of 7 km s^{-1} and a typical error of 0.3 km s^{-1}, this choice ensures that all the selected stars are likely to fulfil one of the criteria for youth, significant rotational velocity. Among the 220 stars thus selected, 129 were suitable for observations in the southern hemisphere and were indeed observed spectroscopically with the 1.4 m ESO CAT telescope in various observing runs. Photometric observations of 90 of these stars were also carried out with the 50 cm ESO telescope, while for the remaining stars of the sample we used photometric data from either the Hipparcos catalogue (Perryman et al. 1997) or from the literature.

Since the CORAVEL sample is unbiased with respect to sky distribution and complete up to $V\simeq 8.6$, this study represents also a detailed description of the characteristics of solar-type stars with high rotational velocity in the solar neighborhood. However, since the width of the CORAVEL cross-correlation profile depends slightly on the spectral type (de Medeiros & Mayor 1999), by selecting the stars with this method we have indirectly set a selection criterium which slightly depends on the $B-V$: for a given cross-correlation width, warmer stars will have slightly higher rotational velocities than cooler ones. Therefore, we would expect that some of the cooler stars which were at the limits of the selection criteria will be found to have a slightly lower $v\sin i$. Finally, we note that the cross-correlation width also depends on the luminosity class. However, such a fact is important only for luminosity classes higher than III.

2.2. Photometric observations

For 90 stars of our sample, $UBV(RI)_{\rm c}$ photometry has been obtained at the European Southern Observatory (ESO–La Silla, Chile) during several observing runs (19 November–3 December 1993; 24 November–4 December 1994; 15–28 January 1995 and 1–12 October 1995), by using the 50 cm ESO telescope equipped with a single channel photon-counting photometer, a thermoelectrically cooled Hamamatzu R-943/02 photomultiplier and standard ESO filters matching the $UBV(RI)_{\rm c}$ system. The observed V-band magnitudes and colors are listed in Appendix 1. Details on the observation and reduction procedures are given in Cutispoto (1998). The typical accuracy of our absolute photometry is of the order of 0.01 magnitudes. For some stars larger errors, up to 0.02 magnitudes, were obtained for the $U-B$ color. These values are indicated in Appendix 1 with the symbol ":".

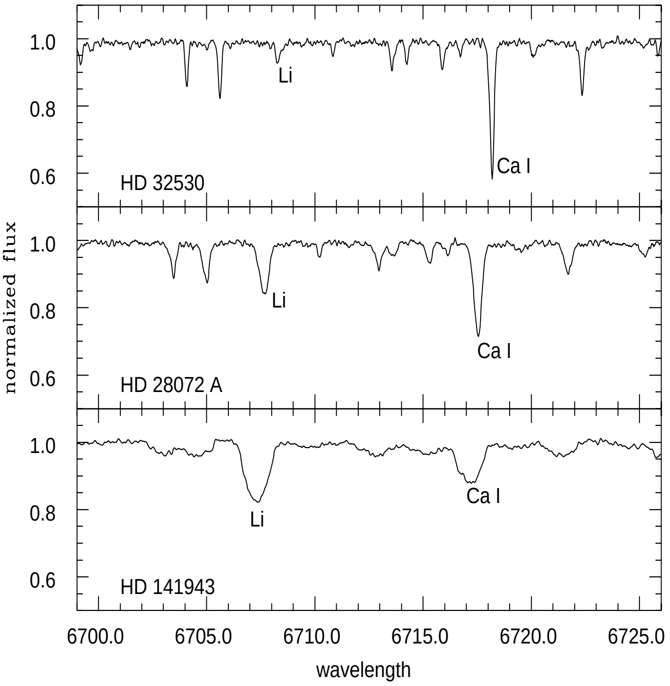

Fig. 1. Normalized spectra in the Li I region for the stars HD 32530, HD 28072A and HD 141943. The increase in both the Li I line EW and the $v\sin i$, from the upper to the lower panel, is clearly visible (although stars with higher $v\sin i$ do not always also have larger Li I line EW).

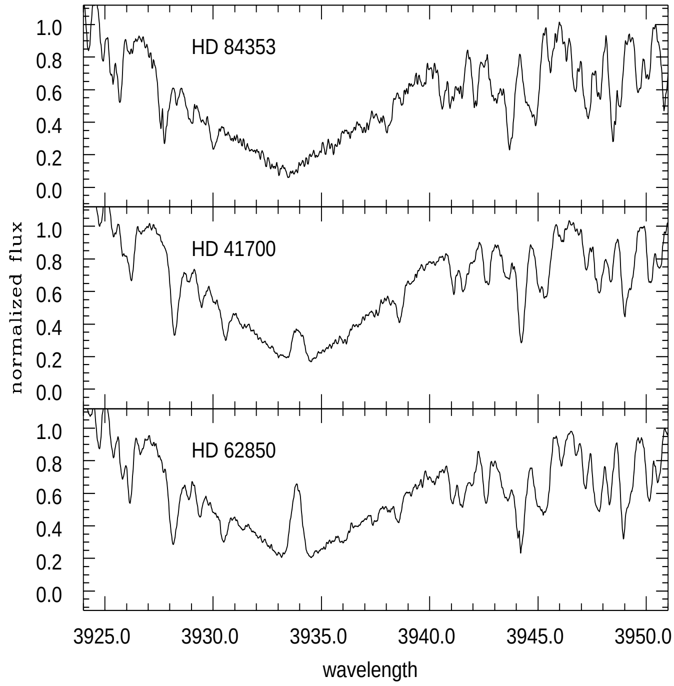

Fig. 2. Normalized spectra in the Ca II K region for the stars HD 84353, HD 41700 and HD 62850. The increase in emission is clearly visible.

For the stars we were unable to observe, we took the photometric data from the Hipparcos catalogue (Perryman et al. 1997) or from the literature. Some stars were observed several times, and information on the occurrence of optical variability, if any, is given in Appendix 2.

2.3. Spectroscopic observations

High resolution spectroscopy has been obtained at ESO using the Coudé Echelle Spectrometer (CES) fed by the 1.4 m CAT telescope. Coupling the CES with the Long Camera, and a 2000×2000 CCD detector with a 15 μm pixel size, the set-ups were fixed to cover two wavelength regions centered at 6705.5 Å (Li I region, $R \simeq 100\,000$) and at 3938.5 Å (Ca II K region, $R \simeq 60\,000$), respectively. The spectra in the Li I region were taken during the observing runs 22–27 September 1993 and 26–31 March 1994; they cover about 55 Å (6680 Å–6735 Å) and have a typical signal-to-noise $S/N \simeq 110$. The spectra in the Ca II K region were taken during the observing runs 28 August–4 September 1994 and 28 January–2 February 1995; they cover about 31 Å (3923 Å–3954 Å) and have a typical signal-to-noise $S/N \simeq 50$. The data reduction was performed by using standard procedures within the IRAF package. After bias subtraction the spectra were flat-fielded by using the spectrum of a quartz lamp. A Th-Ar lamp was used for wavelength calibration. Three typical spectra in the Li I region, of stars with increasing rotation rates and Li line equivalent width, are shown in Fig. 1. Three typical spectra in the Ca II K region, normalized at 3950.5 Å, of stars with increasing Ca II K line emission are shown in Fig. 2.

3. Analysis

3.1. Radial velocities

Radial velocities (*RV*) were obtained from our spectra and were used to ascertain the single or binary nature of the stars in our sample. The Li I and Ca II K regions contain a large number of unblended lines of various strengths suitable for accurate *RV* measurements. The data reduction was performed by standard procedures within the IRAF package, fitting the strongest lines present in each spectrum (which are listed in Table 4 of Cutispoto et al. 1999) by Gaussian profiles. The resulting RVs from the individual lines have been averaged, and heliocentric corrections have been applied. The typical *RV* accuracy for sharp-lined stars is ± 2 km s^{-1}, the error increasing to about ± 5 km s^{-1} for stars with $v\sin i > 40$ km s^{-1}. Since each observation was not encompassed by Th-Ar exposures, we have also to consider the error due to the stability of the CES during one night. This drift is less than 1.5 km s^{-1}, as recently established by accurate *RV* measurements for exoplanets search (Kürster, private communication). Our *RV* determinations are listed in Appendix 3. Additional information on the *RV* variability was extracted from the database of CORAVEL observations (Nordström et al. 1996).

3.2. Inferred spectral classification

For most of the stars in our sample a spectral classification, usually from the Michigan Spectral Catalogue, is available in the SIMBAD database. However, for each star we tried to better define or further constrain the spectral type and the luminosity class and to investigate the presence of companions. To accomplish this task for each star we used multicolour photometry, *RV* information from our spectra and from the CORAVEL database, the intensity of the Ca I 6717.7 Å line (such line is present in our spectra in the Li I region) and the distance from the Hipparcos catalogue (Perryman et al. 1997). Details on this method can be found in Cutispoto et al. (1999, 2000). Reddening has been considered negligible for all stars. We list in Table 1 the single stars in the F5 V–G9 V and F6 III–G7 III spectral ranges ($B-V$ ranges from 0.48 to 0.79 and from 0.47 to 0.93 for the dwarf and giant stars, respectively) and the visual binaries (VBs) or spectroscopic binaries (SBs) for which at least the primary component falls in the same spectral intervals.

We have found that 19 of the stars of our original sample are not solar-type stars: they do not fit the above requirements or have peculiar spectra. They were included in the sample just because their spectral types were not accurately known or by mistake. These stars have been listed separately in Table 3 and have been excluded from the analysis presented here and in PAP II. We are confident that the spectral types we deduced are very reliable, with typical uncertainties of the order of ±1 spectral subclass. Spectral types with uncertainties greater than ±2 spectral subclasses are indicated in Tables 1 and 3 with the symbol ":". The absolute magnitudes (M_V) listed in Tables 1 and 3 were obtained from the trigonometric (D) or photometric ($d_{\rm ph}$) parallax. For the components of SBs the M_Vs of the individual components were estimated from our spectral classification; these values are given in Appendix 2.

3.3. Rotational velocities

We computed rotational velocities from the spectra in the Li I region by using the cross-correlation task *"FXCORR"* of the IRAF package. The *FWHM* of the cross-correlation peak thus obtained can be used to estimate the $v\sin i$ (Soderblom et al. 1989). We calibrated the method by using seven stars of known $v\sin i$. The cross-correlation method gives reliable results in the 5–60 km s^{-1} range. For values higher than 60 km s^{-1} the Gaussian fit we used is no longer adequate, and the rotational broadening of the lines represents a large fraction of the observed spectral range. The error for high signal-to-noise spectra is of the order of ±2 km s^{-1}. Additional information about the $v\sin i$ of the stars of our sample was extracted from the CORAVEL database (for a description and references on these determinations, see Benz & Mayor 1984; de Medeiros & Mayor 1999). The rotational data from our spectra ($v\sin i_{\rm cp}$) and from CORAVEL ($v\sin i_{\rm CO}$) are listed in Tables 1 and 3. The comparison of the two datasets gives a very good agreement, in most cases ($v\sin i_{\rm cp}$) − ($v\sin i_{\rm CO}$) is of the order of ±1–2 km s^{-1} or less.

As described in Sect. 2.1, our sample was selected on the basis of one of the characteristics of youth, i.e. a high rotation rate. Here we define this selection criterion more precisely. The rotation for stars in the Hyades cluster (age ≃0.8 Gyrs) has been studied by Gaigè (1993) and by Radick et al. (1987). There is a very high dispersion of rotational velocities for Hyades stars hotter than $T_{\rm eff}\simeq 6600$ K (see Fig. 8 in Gaigè 1993). The mean rotational velocity is of about 21 km s^{-1} for stars with $T_{\rm eff}\simeq 6400$ K and of about 17 km s^{-1} for stars with $T_{\rm eff}\simeq 6200$ K ($B-V=0.52$, spectral type F6/7 V). According to Radick et al. (1987) the rotational velocities in the Hyades decline smoothly from about 11 km s^{-1} for F8 stars ($T_{\rm eff}\simeq 6078$ K) to about 4–5 km s^{-1} for K0 stars ($T_{\rm eff}\simeq 5207$ K). Therefore, for a star of a given spectral type we define *"high rotation"* to mean a rotational velocity similar to or higher than the value observed for stars of comparable spectral type in the Hyades. In the upper panel of Fig. 3 we plot the $v\sin i_{\rm cp}$ values of our entire sample and the mean rotational curve for the Hyades. In the bottom panel of Fig. 3 the lowest rotational rates are examined in detail (the Sun's position is also shown). For a large sample of stars, assuming a random distribution of rotation axes, the expected ($v\sin i/v$) ratio is $\pi/4=0.79$ (Chandrasekhar & Münch 1950). Thus, to take into account the statistical correction to the $v\sin i$, in Fig. 3 we also plotted a curve which corresponds to the Hyades rotation values diminished by a factor 0.79, and, finally, an even lower curve corresponding to the latter values reduced by 1 km^{-1}, which is one half of our mean error in the $v\sin i$ determination. In our analysis for any $B-V$ we retained all the stars with a $v\sin i$ higher than the value defined by the lower curve. Following this criterion, the star HD 125764 (whose position in Fig. 3 is indicated with the symbol ◇) was excluded from the analysis.

3.4. Li abundances

We obtained Li abundance ($A_{\rm Li}$), including n-LTE corrections, by measuring the equivalent widths of the Li I 6707.8 Å doublet and following the procedure described by Carlsson et al. (1994). We used the "corr_nlte" routine made available from "`ftp.astro.uio.no`". This routine requires the following input data: $A_{\rm Li}$(LTE), $T_{\rm eff}$, $\log g$, and [Fe/H]. In a few cases in which one or more of the above parameters was out of the range allowed by the above mentioned routine, we computed $A_{\rm Li}$ assuming LTE conditions. The differences between n-LTE and LTE values are of the order of 0.1–0.3 dex. More critical are the aspects of precise $T_{\rm eff}$ evaluation and of deblending in presence of composite spectra. An accurate determination of the stellar parameters is a fundamental step to perform this task properly, because it allows to infer fairly accurate $T_{\rm eff}$ and also to give proper weights to the binary

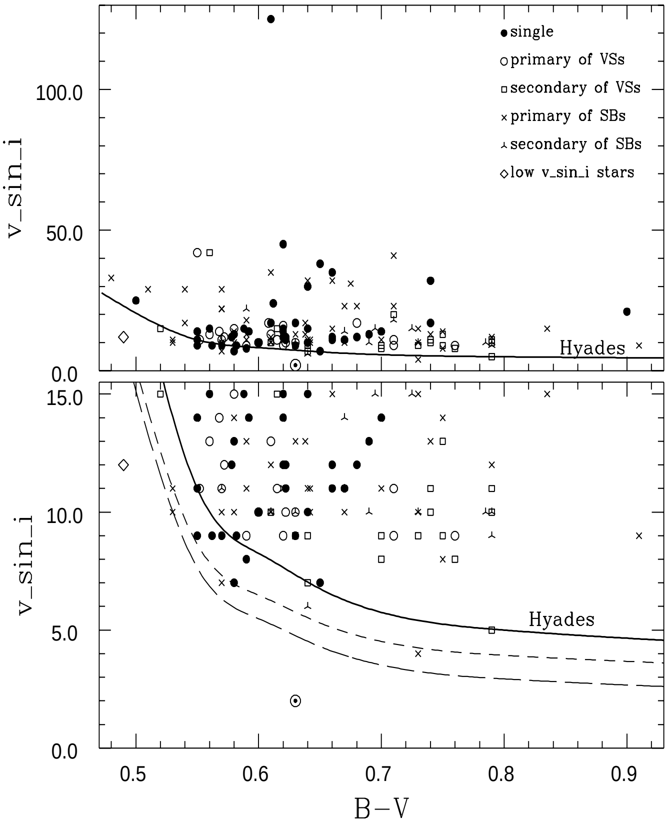

Fig. 3. $v\sin i$ vs. $B-V$ relationship for the stars in our sample. The complete sample (upper panel) and the stars of the sample with $v\sin i$ smaller than 15.5 km s^{-1} (bottom panel) are compared with Hyades rotational velocities. The solid curve is the mean rotational velocity of the Hyades (Gaigè 1993; Radick et al. 1987). The short-dashed curve was obtained considering a ($v\sin i/v$) ratio of $\pi/4$ (Chandrasekhar & Münch 1950); the long-dashed curve was obtained by subtracting half of the mean error in our $v\sin i$ determination from the short-dashed curve. The star HD 125764, which is indicated with the symbol ◇, was excluded from the analysis. See also Sect. 3.3.

components. We opted to derive the $T_{\rm eff}$ from the $B-V$ vs. $T_{\rm eff}$ scale by Flower (1996). For single stars and for a few well separated VBs the $B-V$ we used are from our photometric observations or from the Hipparcos database. For close VBs and for SBs, the $B-V$ of each component was deduced from our spectral classification and the contribution of the continuum of the two stars on the observed equivalent widths of the Li lines was taken into account. Overall, in the spectral range considered here we estimate an average $T_{\rm eff}$ uncertainty of ±150 K, including errors due to differences in metallicity up to 0.3 dex, which results in $A_{\rm Li}$ uncertainties no greater than ±0.2 dex for single stars and of the order of ±0.3 dex for close VBs and SBs. Finally, the errors introduced in the $A_{\rm Li}$ determination by the Li line EW uncertainties range from ± 0.15 dex for EW of the order of 10 mÅ to ± 0.02 dex for EW larger than 100 mÅ.

Table 2. Comparison of our $A_{\rm Li}$ with data from the literature: Star name (Name), $A_{\rm Li}$ computed by us in n-LTE (nlte) and in LTE (lte), $A_{\rm Li}$ from the literature (L), with values computed in LTE indicated with the symbol "*", difference between our values and literature values (Δ), reference for the literature data (r).

Name	nlte	lte	L	Δ	r
HD 105	3.1	3.2	3.4*	0.2	1
HD 13183	3.1	3.4	3.3*	0.1	2
HD 27989	2.8	2.9	2.9*	0.0	3
HD 41700	2.9	3.0	2.9	0.0	4
HD 45270	3.0	3.1	3.1*	0.0	2
HD 84323	3.1	3.3	3.5*	0.2	2
HD 171488	3.2	3.5	3.1	0.1	5
HD 202917	3.0	3.2	3.3*	0.1	6
HD 212697	2.7	2.8	2.8*	0.0	7
HD 212698	2.8	2.8	2.9*	0.1	7
HD 222259 A	3.1	3.3	3.2*	0.1	6

References: 1) Favata et al. (1998); 2) Torres et al. (2000); 3) Barrado y Navascues & Stauffer (1996); 4) Randich et al. (1999); 5) Strassmeier et al. (2000); 6) Soderblom et al. (1998); 7) Pallavicini et al. (1987).

Our $A_{\rm Li}$ can be compared with other determinations, since some of the stars in our sample have been independently observed by other authors. The comparison for eleven stars gives a reasonable agreement: our values and literature values never differ by more than 0.2 dex (see Table 2). It should be noted that our careful spectral classification allows us a more accurate analysis in some specific case. For instance, a G1 IVp spectral classification, SB1 nature and $A_{\rm Li}=1.35$ were reported for HD 14643A by Randich et al. (1993). However, from our spectra HD 14643A turned out to be an SB2 system and we were able to infer a more reliable spectral classification and to derive separate $A_{\rm Li}$ for the two components. Similar cases occur for HD 17084 and HD 222259B, for both of which we were able to determine an SB2 nature and to infer $A_{\rm Li}$ for each component. To summarize, we have been able to infer $A_{\rm Li}$ values or upper limits for 42 single stars (28 of which are MS stars), 20 primary components of VBs (19 of which are MS stars), 15 secondary components of VBs (12 of which are MS stars), 47 primary components of SBs (30 of which are MS stars), and 14 secondary components of SBs (10 of which are MS stars). For three stars in our sample (HD 16160, HD 174429 and HD 206860) we do not have a spectrum in the Li I region. For HD 206860 the $v\sin i$ and the $A_{\rm Li}$ listed in Table 1 are from Gaidos (1998).

3.5. Ca II K line

A detailed analysis of the Ca II K line is beyond the purpose of this paper. Here we used the spectra in the Ca II K region only for RV determinations (Appendix 3) and report on the presence of Ca II K emission (Appendix 2). For 20 stars (HD 92648, HD 120864, HD 122893, HD 124784, HD 125764, HD 127352, HD 130166, HD 133119,

HD 135449, HD 136160, HD 141710, HD 141943, HD 143809, HD 144515, HD 145112, HD 147633, HD 149139, HD 150108, HD 150711 and HD 199672) we were not able to obtain a spectrum in the Ca II K region and, hence, we cannot make any statement on the Ca II K line.

3.6. X-ray luminosities

To compute the X-ray luminosities of the star in our sample we searched the ROSAT all-sky survey catalogue (Voges et al. 1999) and, in case of detection, we derived the ROSAT PSPC X-ray luminosity in the 0.2–2.5 keV energy band. The conversion from count rates to X-ray fluxes has been done using the conversion factor $ECF = (8.31 + 5.30HR) \times 10^{-12}$ erg cm^{-2} given by Fleming et al. (1995).

4. Discussion

In this section we discuss our results, centering on the composition of the sample. The relations involving $A_{\rm Li}$, the X-ray emission and the $v\sin i$ will be discussed in PAP II. A summary of the stellar parameters is given in Tables 1 and 3 where for each star we list the brighest V magnitude so far observed, a binarity flag, the spectral type inferred by us, the distance reported in the Hipparcos catalogue or the photometric distance deduced by us, the absolute V-band magnitude from the trigonometric or photometric parallax, the $v\sin i$ inferred by us ($v\sin i_{\rm cp}$), the $v\sin i$ by CORAVEL ($v\sin i_{\rm CO}$), the Li line EW, the $A_{\rm Li}$ computed by us under n-LTE conditions (the few values computed under LTE conditions are indicated with ":") and the logarithm of the X-ray luminosity (in units of erg s^{-1}).

Our data allow us to discriminate with high confidence between binary and single stars and to make different analyses for the two categories. We find that 17 stars in our sample (HD 12695, HD 13183, HD 18809, HD 27989A, HD 41190, HD 47718, HD 70359, HD 74254, HD 104467, HD 120864, HD 125764, HD 127352 A, HD 135449, HD 147802, HD 165045, HD 182370 and HD 218602), given as single in the SIMBAD database are indeed SB1 systems. Moreover, another 13 stars in our sample (HD 50081, HD 61299, HD 62558, HD 73204, HD 77569, HD 80332, HD 92648 A, HD 104551, HD 133119, HD 149139, HD 176247, HD 197192 and HD 223537) given as single in the SIMBAD database are indeed SB2 systems (one of them, HD 133119, is likely to be an SB3 system).

4.1. The B-V vs. M_V diagram

Figure 4 shows the colour-magnitude diagram for the stars in our final sample (i.e. the stars listed in Table 1). We indicate with different symbols the single stars and the components of VBs and SBs. We include all stars (single or components of VBs or SBs) according to the criteria described in Sects. 3.2 and 3.3. For single stars, and for a few well separated VBs, the $B-V$ is derived from our photometric observations or from the Hipparcos database and the M_V directly from the trigonometric or photometric parallax. For the components of close VBs and for SBs the $B-V$ and M_V of each component (see Appendix 2) were deduced from our spectral classification, their combinations always fitting the observed values. We were not able to obtain separate spectra for a number of very close VBs (separation of the order of 1″ or less). Most of these systems were actually identified as VBs only by the Hipparcos satellite, but they appear as SB2 in our ground-based observations (see Appendix 2 for details). Of course the VBs that appear as SB2 in our spectra are indicated as VBs in our plots.

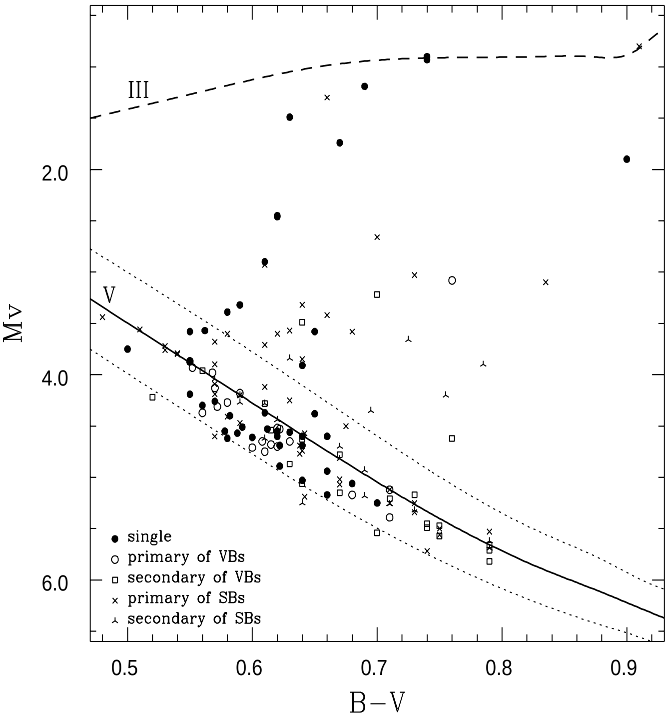

Fig. 4. The $B-V$ vs. M_V diagram for the stars in our sample. The single stars, the components of VBs and of SBs are indicated with different symbols. The continuous line and the long-dashed lines are the MS and the class III giant sequences, respectively, from Hypparcos data (Houk et al. 1997); the short-dashed lines indicate the limits of the dispersion of MS stars from Hipparcos data.

Not all the stars in our sample are on the main sequence; a large number of them is clearly above it. As we shall show in PAP II, some of them are likely to be genuine giants or subgiants, while HD 104467, HD 106506 and HD 141943, for which we measured $A_{\rm Li} = 3.3$, are genuine PMS objects. We shall show also that 6 single stars in our sample have an $A_{\rm Li}$ higher than that of the Pleiades and can be considered bona-fide ZAMS stars.

It is worth pointing out that in our final sample of 110 stars 42 ($\simeq$38%) are single, 33 ($\simeq$30%) are VBs (13 of which contain at least one SB) and 35 ($\simeq$32%) are SBs, which yields a single:binaries ratio of 38:62. This value has to be compared with the single:double:triple:quadruple ratios of 57:38:4:1 (or 51:40:7:2 in a less restrictive case) found by Duquennoy & Mayor (1991) for solar neighbourhood field stars in the spectral range F7-G9, luminosity classes IV-V, V and VI. Hence, we find a significantly lower number of single stars in our sample. However, this was to some extent expected: our sample consists of fast rotators, and binaries, in particular tidally locked systems, are therefore selected preferentially. On the other hand, in the analysis presented in PAP II the components of VBs which do not contain SBs have been included in the sample of single stars. In fact, the long-period binary stars, and in particular the components of VBs, are not subject to the phenomena, such as mass exchange between the components and/or synchronization between the rotational and orbital periods due to tidal interactions, which can significantly change the evolution and/or the rotational history of a star.

5. Conclusion

In this paper, the results of high-resolution spectroscopy and high-precision photometry of a sample of 129 fast rotating late-F and G-type nearby stars have been presented. The sample was selected from a CORAVEL survey of late-F to G-type stars brighter than $V \simeq 8.6$. Our data have been combined with further information from the Hipparcos satellite, CORAVEL and the ROSAT satellite database. We have inferred accurate spectral types and computed radial velocities, $v \sin i$, $A_{\rm Li}$, and X-ray luminosities.

We have investigated the single or binary nature of sample stars, finding a single-star to binary ratio of 38:62. We have been able to infer $A_{\rm Li}$ values or upper limits for 42 single stars, 35 components (primary or secondary) of VBs and 61 components (primary or secondary) of SBs. We find a high incidence of close binaries (30 stars have been identified as SBs for the first time) and of young single disk stars (at least 9 stars can be considered bonafide PMS or ZAMS objects). Finally, information on the presence of Ca II K emission and on optical variability is given for some of the stars of the sample.

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Appendix 1: Photometric data obtained at La Silla

Table 4 lists the photometric data obtained by us using the 0.5-m ESO telescope. The typical accuracy of V-band magnitudes and color indices is of the order of 0.01 magnitudes; larger errors are indicated by the symbol ":" (see Sect. 2.2 for further details).

Appendix 2:

We here provide notes on some individual stars. Our classification work has greatly benefited from data collected by the Hipparcos satellite and presented by Perryman et al. (1997). In particular, the trigonometric parallax was often a key parameter for choosing between possible spectral classifications. Moreover, the magnitude difference between the components was very useful for studying VBs. We give the absolute magnitudes inferred for primary and secondary components of SBs as $M_{\rm Va}$ and $M_{\rm Vb}$, respectively.

HD 105: Favata et al. (1998) reported $A_{\rm Li} = 3.4$ and $L_{\rm X} = 29.20$; $v \sin i = 13$ km s^{-1} was listed by Favata et al. (1995). Constant RV, according to Duflot et al. (1995); may be a variable star. We detected Ca II K emission in both collected spectra.
HD 377: Ca II K emission is present in both collected spectra.
HD 531: a VB ($\rho = 5\farcs27$), separate spectra of the two components were obtained; Ca II K emission from both components is present; optical variability is possible.
HD 3405: an orbital period of 3.7418 days is reported by Tokovinin (1997); $M_{\rm Va} = 4.25$, $M_{\rm Vb} = 4.35$. We detect Ca II K emission, including contributions from both components.
HD 4655: a VB ($\rho = 0\farcs24$) seen as SB2 in our spectra; we do not confirm the suspected RV variability of the primary component listed in the CORAVEL database.
HD 12695: Li$_{EW}$ of about 20 mÅ is given by Torres et al. (2000). It is reported as SB2 by CORAVEL; however, although we confirm the RV variability, there is no evidence for the secondary component in our spectra. We detect Ca II K emission.
HD 13183: was also studied by Torres et al. (2000), who reported Li$_{EW} = 241$ mÅ, $RV = 9.9$ km s^{-1}, $v \sin i = 23$ km s^{-1} and $A_{\rm Li} = 3.3$ and classified this star as a member of the Horologium association. The suspected RV variability reported in the CORAVEL database is confirmed by our data, and the star is listed as an unresolved variable in the Hipparcos catalogue; the possible companion has to be a very late-type star. We detect Ca II K emission.

HD 14643 = BQ Hyi: a VB ($\rho = 1\farcs42$) whose brighter component is also an eclipsing binary. An orbital period of 18.379 days and $v\sin i = 40$ km s^{-1} are reported by Balona (1987); combined out-of-eclipse colors were obtained by Lloyd-Evans & Koen (1987), and $v\sin i = 30$ km s^{-1} and $A_{\rm Li} = 1.35$ are reported by Randich et al. (1993), We detect Ca II K emission, including contributions from both components. $M_{\rm Va} = 1.87$, $M_{\rm Vb} = 3.32$.
HD 16160: we detect Ca II K emission with a central reverse.
HD 17084 = UX For: a photometric period of 0.957 days was reported by Lloyd-Evans & Koen (1987); $v\sin i$ of 48 and 40 km s^{-1} were reported by Washüttl & Strassmeier (1995) for the two components, respectively, and $A_{\rm Li} = 1.6$ was computed by Randich et al. (1993). We detect separate Ca II K emission from both components; $M_{\rm Va} = 5.25$, $M_{\rm Vb} = 6.37$.
HD 17332: VB ($\rho = 3\farcs64$). We obtained separate spectra of both components; Ca II K emission is evident for both components.
HD 18809: an *RV* range of about 17.4 km s^{-1} is present in the CORAVEL database; we detect Ca II K emission from the primary component. $M_{\rm Va} = 5.19$, $M_{\rm Vb} = 7.99$.
HD 19716: a VB ($\rho = 0\farcs16$) seen as SB2 in our spectra.
HD 20837: a VB ($\rho = 0\farcs95$ is listed in the Hipparcos catalogue and $\rho = 1\farcs13$ in 1995.01 is given by Heintz 1996); optical variability is likely. The primary (A) component is an SB2 system ($M_{\rm VAa} = 4.20$, $M_{\rm VAb} = 5.26$), in which we detect Ca II K emission from the G2V component; to fit the magnitude difference and the $B - V$ color of A and B components, the latter has to be a slightly evolved star.
HD 27947: we detect Ca II K emission.
HD 27989: a VB ($\rho = 0\farcs25$) seen as SB2 in our spectra; it is a variable star; $A_{\rm Li} = 2.87$ and separate magnitudes for the two components are in Barrado y Navascues & Stauffer (1996). A total mass $M_1 + M_2 = 1.77\,M_\odot$ is given by Soederhjelm (1999); $v\sin i$ of 5.2 and 7.3 km s^{-1} for the two components, respectively, are listed by Strassmeier et al. (2000). The primary component is an SB1, as indicated by the CORAVEL data; the companion is likely to be an M-type star. We detect Ca II K emission from the G3V component.
HD 28072: a VB ($\rho = 1\farcs22$); our spectra refer to the primary component and we detect Ca II K emission.
HD 36869: a variable star (P = 1.31 day) already studied by our group (Cutispoto et al. 1999); we detect Ca II K emission.
HD 38397: we detect Ca II K emission.
HD 41190: the spectrum of the primary component is typical of a giant; optical variability is possible.
HD 41700: is the C component of a triple system; AB (=HD 41742) and C components are 196″ apart; AB is a close ($\rho = 4\farcs8$) VB. $A_{\rm Li} = 2.9$, $v\sin i = 16.2$ km s^{-1} and $M = 1.2\,M_\odot$ are reported by Randich et al. (1999); we detected Ca II K emission.
HD 45270: this star was also studied by Torres et al. (2000) who report $\mathrm{Li}_{EW} = 149$ mÅ, $RV = 32$ km s^{-1}, $v\sin i = 18$ km s^{-1} and $A_{\rm Li} = 3.1$; we detect Ca II K emission. The star has an active late-K companion ($\rho = 16''$, $\Delta V \simeq 4.1$).
HD 47718: our two *RV* measurements give an almost constant value, but the star is reported as SB1 by CORAVEL; the companion, if any, is likely to be a K-type or later star. We detect Ca II K emission with a central reverse.
HD 48676: a VB ($\rho = 2\farcs41$); our spectra refer to the primary component, and we detect Ca II K emission.
HD 50081: is likely to be a variable star; $M_{\rm Va} = 3.72$, $M_{\rm Vb} = 4.04$.
HD 50716: is classified as a marginal Ba II with $M_{\rm V} = 0.9$ by Gomez et al. (1997); probably variable.
HD 58249: probably variable. The star is listed as single in the CORAVEL database; however, two clear systems of lines are visible in our Li I spectrum, and low amplitude RV variability was also detected by us. From our data and from the parallax we suspect that this system consists in fact of three very close stars, two of which ($M_{\rm Va} = 3.76$, $M_{\rm Vb} = 4.28$) constitute an SB1 system not close enough to be detected by CORAVEL.
HD 61299: we detect Ca II K emission from the primary component; $M_{\rm Va} = 3.80$, $M_{\rm Vb} = 4.93$.
HD 61866: a VB ($\rho = 0\farcs39$); our spectra refer to the primary component, and we detect Ca II K emission with a central reverse.
HD 62558: we detect separate Ca II K emissions from both components; $M_{\rm Va} = 3.32$, $M_{\rm Vb} = 3.84$.
HD 62850: variable star from our photometry; listed as a single star by Mason et al. (1998). We detect Ca II K emission.
HD 68676: we detect weak Ca II K emission.
HD 71285: a variable star (P = 1.35 days) already studied by our group (Cutispoto et al. 1999); here we revise the spectral classification and confirm the presence of Ca II K emission with a central reverse from the primary component.
HD 73204: we detect Ca II K emission; $M_{\rm Va} = 3.56$, $M_{\rm Vb} = 5.69$.
HD 74254: clear *RV* variability is detected in our spectra, but we cannot speculate on the nature of the companion; the Ca II K spectrum has low signal-to-noise, but clear emission with a possible central reverse is present.
HD 74534: we detect Ca II K emission.
HD 77569: $M_{\rm Va} = 4.60$, $M_{\rm Vb} = 5.25$. The Li line is detectable in the spectrum of the primary component only; a weak Ca II K emission, probably from the G3V component, is observed.
HD 80332: $M_{\rm Va} = 3.03$, $M_{\rm Vb} = 4.20$. The Li line is detectable in the spectrum of the primary component only; we detect Ca II K emission with a central reverse from the primary component.
HD 80846: we detect a weak Ca II K emission.
HD 81997: SB1 ($M_{\rm Va} = 3.44$, $M_{\rm Vb} = 7.59$) with a 7.7 year period (Duquennoy & Mayor 1991); there is an optical companion ($\Delta V \sim 3.3$) about $65\farcs4$ apart.
HD 82159 B = SAO 98616: a star already studied by our group (Cutispoto et al. 1999) together with its

visual companion HD 82159 A ($\rho = 13\farcs9$, $V = 8.66$, G9V+K4:V, $D = 47$ pc).

HD 84323: our observations show optical variability in the V-band with an amplitude of about 0.09 magnitudes; Ca II K emission was detected. $M_{\rm Va} = 4.74$, $M_{\rm Vb} = 8.49$. this star was also studied by Torres et al. (2000) who report $\mathrm{Li}_{EW} = 223$ mÅ, $RV = 19.6$ km s^{-1}, $v\sin i = 30$ km s^{-1} and $A_{\rm Li} = 3.5$.

HD 85474: a VB ($\rho = 0\farcs71$) found as SB2 in our spectra; we detect Ca II K emission with a central reverse in the spectrum of the primary component.

HD 89449: a δSct-type variable star; reported as SB1 by CORAVEL. The companion, if any, is later than G5V; $v\sin i$ of 17.3 km s^{-1} and $A_{\rm Li} < 1.3$ were reported by Lèbre et al. (1999).

HD 90737: a VB ($\rho = 0\farcs15$) found as SB2 in our spectra. The C component, $1\farcs35$ apart, was also in the slit; the presence of CaII K emission from the B or C component is possible.

HD 92648: a VB ($\rho = 2\farcs02$) whose primary component is an SB2 ($M_{\rm Va} = 3.79$, $M_{\rm Vb} = 4.55$); the Li line is detectable only in the spectrum of the Aa component.

HD 94853: is the eclipsing binary QR Hya; we detect Ca II K emission from both components. $M_{\rm Va} = 4.12$, $M_{\rm Vb} = 4.44$.

HD 96843: we detect Ca II K emission.

HD 98622: was classified as a *"class I"* ($M_{\rm V} = -1.5$, $d_{\rm ph} = 643$ pc) barium star by Gomez et al. (1997); otherwise it would be a G9:III: ($d_{\rm ph}$=198 pc) star. The presence of an early-type companion, not close enough to produce detectable RV variability, is likely; we detect Ca II K emission.

HD 99010: was classified as a metal deficient star ($M_V = 2.5$, $d_{\rm ph} = 195$ pc) by Bartkevicius (1984) and as a weak-lined star ($M_{\rm V} = 3.15$, $d_{\rm ph} = 145$ pc) by Eggen (1984). CORAVEL reports a SB2 nature which is confirmed by our RV measurements.

HD 101117: we detect Ca II K emission.

HD 104467: a T Tau-type star in the Chamaleon star-forming region. $R = 2.2\,R_\odot$, $M = 1.60\,M_\odot$ and an age of 7 Myr are given by Terranegra et al. (1999); Covino et al. (1997) compute $v\sin i = 21 \pm 3$ km s^{-1} and report an RV of 10.0 ± 2 km s^{-1}, which is quite different from the values obtained from our spectra. The CORAVEL database also reports RV variability; hence, this star is likely to be a very young SB1 system, although we cannot speculate at this time on the nature of the eventual companion. We detect Ca II K emission.

HD 104551: this star is seen as SB2 in our spectra. An RV variability range of only 0.53 km s^{-1} is present in the CORAVEL database; however, weak but significant RV variability was detected by us, and we believe that this star is a sort of *"marginal"* SB2 system ($M_{\rm Va} = 4.57$, $M_{\rm Vb} = 4.70$) with the two components not close enough to generate RV variability on a day-to-week timescale. We detect Ca II K emission, including contributions from both components.

HD 105578: an RV Tau-type variable (RU Cen); a period of 64.60 days ($V = 8.53$–9.81, $B - V = 0.50$–1.02) was found by Pollard et al. (1996). It seems to be single (Pollard et al. 1997); the trigonometric parallax has a large error.

HD 106506: is a single (Mason et al. 1998) member of the Lower Centaurus Crux association (De Zeeuw et al. 1999). Soderblom et al. (1998) inferred $v\sin i = 70 \pm 8$ km s^{-1} and detected a strong Li I line and the presence of circumstellar/interstellar features; however, the possible SB2 nature they inferred in not confirmed by us. The fit of the parallax is obtained by assuming a G0 star with $R = 1.9\,R_\odot$; our $v\sin i$ determination has an error of at least ± 7 km s^{-1}. We detect Ca II K emission.

HD 108361: a VB ($\rho = 0\farcs23$), seen as SB2 in our spectra.

HD 113553: we detect Ca II K emission.

HD 116402: is a member of the Lower Centaurux-Crux association (De Zeeuw et al. 1999).

HD 118100 = EQ Vir: a well-known flare star; we detected very strong Ca II K emission.

HD 118981: Henry et al. (1995) report optical variability with an amplitude of 0.01 magnitudes and $P_{\rm phot} = 5.94$ days; they also computed $v\sin i$ of 7 ± 1 and 7 ± 4 km s^{-1} for the two components, respectively. The Li line is detectable only in the spectrum of the primary component; we detect Ca II K emission from the primary component. Our spectral classification agrees well with the one inferred by Henry et al. (1995); $M_{\rm Va} = 4.19$, $M_{\rm Vb} = 6.03$.

HD 120864: weak RV variability was obtained by CORAVEL; $M_{\rm Va} = 3.68$, $M_{\rm Vb} = 4.27$.

HD 121454: a VB ($\rho = 0\farcs12$) seen as SB2 in our spectra; we assumed that the G4IV/III and G2IV/III components have radii of $2.9\,R_\odot$ and $2.7\,R_\odot$, respectively ($d_{\rm ph}$ = 71 pc).

HD 124784 = V836 Cen: an eclipsing binary with a 4.2840 day period and G0 V + G7 V components (Brancewicz & Dworak 1980). This classification is in very good agreement with our data, but its photometric distance ($d_{\rm ph} = 91$ pc) does not agree with the value measured by Hipparcos ($D = 65^{+5}_{-4}$ pc); for this star we used absolute magnitudes from the spectral classification ($M_{\rm Va} = 4.20$, $M_{\rm Vb} = 5.32$).

HD 125764: a metal-poor star according to Carney (1980); Norris et al. (1985) report $M_{\rm V} = 4.03$ ($d_{\rm ph} = 131$ pc), in reasonable agreement with the value measured by Hipparcos. The CORAVEL data indicate an SB1 system.

HD 127352: a VB ($\rho = 0\farcs19$) seen as SB2 in our spectra; the CORAVEL data for the primary component show an RV range of 2.1 km s^{-1}.

HD 130166: a VB ($\rho = 0\farcs4$), seen as SB2 in our spectra.

HD 133119: an SB3 system with a G1 IV/V ($M_{\rm Va} = 3.60$) primary component. Two possible companion stars are G8:V/IV: ($M_{\rm Vb} = 3.90$, $v\sin i = 10$ km s^{-1}, $\mathrm{Li}_{EW} = 105$ mÅ, $A_{\rm Li} = 2.3$) and K0:V ($M_{\rm Vc} = 5.88$, $v\sin i = 7$ kms $\mathrm{Li}_{EW} = 195$ mÅ, $A_{\rm Li} = 2.6$); it was classified as a "weak-metal" subgiant by Norris et al. (1985).

HD 135449: our spectrum is almost featureless, and the error in the $v\sin i$ determination is of the order of ± 7 km s^{-1}. It was classified as a metal-weak star ($v\sin i = 25$ km s^{-1}, $A_{\rm Li} < 1.57$) by Glaspey et al. (1994), and Stetson (1991) gives a possible metal-poor blue straggler classification. Bond (1980) reports an RV = -23.0 km s^{-1}, quite different from the value inferred by us; the CORAVEL data confirm the SB1 nature of this star.
HD 136160: has a visual companion (G2V, $d_{\rm ph} = 50$ pc) at about 13″; it is not clear if these two stars constitute a physical pair.
HD 141710: an alternative classification is G3 IV/III ($d_{\rm ph} = 225$ pc).
HD 141943: a PMS variable star already studied by our group (Cutispoto et al. 1999); assuming $R = 1.6$ $R_\odot$ we infer $M_{\rm V} = 3.59$ and $d_{\rm ph} = 72$ pc.
HD 142033: a VB ($\rho = 0\farcs18$) seen as SB2 in our spectra; we detect Ca II K emission from the primary component.
HD 143809: is likely to be a ZAMS star; has an optical companion at about 1 arcmin, but it is unlikely that these two stars constitute a physical pair.
HD 144515 = NQ Ser: Mayor & Mazeh (1987) lists it as a quadruple system with both main components as SB1 ($P_{\rm A} \simeq 4.2855$ days, $P_{\rm B} \simeq 11.005$ days). It was detected as a VB ($\rho = 0\farcs23$) by Hipparcos; in our SB2 spectrum the Aa and Ba components are visible. $v\sin i = 17$ km s^{-1} according to Strassmeier (1994); Fekel (1997) lists $v\sin i$ of 12.1 km s^{-1} and 7.0 km s^{-1} for the two main components, respectively.
HD 145112: the presence of an A-type companion, not detected by us, is reported in the SIMBAD database.
HD 147633: a VB ($\rho = 2\farcs07$) seen as SB2 in our spectra; the secondary component is an SB1 ($M_{\rm Va} = 5.02$, $M_{\rm Vb} = 7.69$).
HD 147802: we detect Ca II K emission with a central reversal.
HD 149139: the Li line is detectable only in the spectrum of the primary component; $M_{\rm Va} = 2.93$, $M_{\rm Vb} = 5.26$.
HD 150108: optical variability is likely.
HD 151770: Mason et al. (1998) lists this star as SB3 or SB4 with evolved components; we compute $M_{\rm Va} = 3.42$ and $M_{\rm Vb} = 3.66$. To fit the Ca I line strength observed in our spectra, the third component has to be a K3:V/IV: star ($M_{\rm Vc} = 5.30$, $v\sin i = 12 \pm 8$ km s^{-1}); the error for the $v\sin i$ of the G3IV/V component is of the order of ± 8 km s^{-1}. We detect Ca II K emission from the third component.
HD 157155: a VB ($\rho = 3\farcs50$); both components are included in our spectra, but the contribution of the secondary component is marginal.
HD 163029: a VB ($\rho = 2\farcs90$). We obtained separate spectra for the two components; the South-West brighter component (A) is an SB1 for which we detected Ca II K emission, the North-East fainter component (B) is an SB2 ($M_{\rm Va} = 6.62$, $M_{\rm Vb} = 7.11$). Nakos et al. (1997) report V = 8.70, $B-V$ = 0.81, $U-B$ = 0.25 and V = 9.26, $B-V$ = 1.08, $U-B$ = 0.88 for the two components, respectively; this photometry is quite different from the values reported in the Hipparcos catalogue, but agrees well with our results. Soderblom et al. (1998) list $v\sin i$ values of 10 ± 3 km s^{-1}, ≤ 4 km s^{-1} and ≤ 3 km s^{-1} for the Aa, Ba and Bb components, respectively; from our spectra the Ab component is likely to be an M4:V star.
HD 165045: we detect Ca II K emission from the primary component; $M_{\rm Va} = 5.56$, $M_{\rm Vb} = 8.02$.
HD 171488 = V889 Her: a variable star with a photometric period of 1.338 days (Henry et al. 1995) already studied by our group (Cutispoto et al. 1999). $A_{\rm Li} = 3.1$ was reported by Strassmeier et al. (2000). The CORAVEL data indicate a possible RV variability with a rather long period; however, even if this is the case, HD 171488 is not a close binary and has been considered as single in the analysis. We detect Ca II K emission.
HD 173427: a VB ($\rho = 0\farcs44$); our spectrum includes only the primary component for which we detect Ca II K emission.
HD 174429 = PZ Tel: a PMS star; Randich et al. (1993) report $A_{\rm Li} = 3.9$ and $v\sin i = 70$ km s^{-1}; Soderblom et al. (1998) report $A_{\rm Li} = 3.2$ and $v\sin i = 58 \pm 7$ km s^{-1}; Barnes et al. (2000) list $v\sin i = 68$ km s^{-1} and an age of 15–20 Myr. We detect Ca II K emission.
HD 175726: we detect Ca II K emission.
HD 176247: we detect Ca II K emission from both components; $M_{\rm Va} = 4.69$, $M_{\rm Vb} = 4.82$.
HD 178085: we detect Ca II K emission.
HD 180445: Soderblom et al. (1998) also classified this star as SB2; they reported $A_{\rm Li} \leq 1.6$, $v\sin i = 8 \pm 3$ km s^{-1} and the presence of a filled-in and variable Hα line. The Hipparcos catalogue lists this star as an unsolved variable; we detect Ca II K emission from both components; $M_{\rm Va} = 5.50$, $M_{\rm V} = 7.22$.
HD 181321: probably variable; it is a member of the 200 Myr old Castor moving group (Barrado y Navascues 1998). We detect Ca II K emission. Seems single from our and from literature RV data, but is reported as SB1 by CORAVEL; the companion, if any, should be at least as late as K5V and is not close. This star was considered as single in the analysis.
HD 182370: $M_{\rm Va} = 2.66$, $M_{\rm Vb} = 4.56$; we detect Ca II K emission from the primary component.
HD 183414: we detect Ca II K emission.
HD 184525: we detect Ca II K emission with a central reversal.
HD 187321: a VB ($\rho = 0\farcs40$); a G5Ib-II: classification for the primary component is given by Ginestet et al. (1999). The magnitude difference between the two components ($\Delta H_{\rm p} = 1.47 \pm 0.04$) is listed in the Hipparcos catalogue; the contribution of the secondary component is not detectable in our spectra.
HD 191179: probably variable. $v\sin i$ values of 38 km s^{-1} and 15 km s^{-1} for the two components, respectively, were computed by Osten & Saar (1998), who also list a K0 IV + G2 V spectral classification; a good fit of the colors is given by a K0 IV ($M_{\rm V} = 2.61$) + G2 IV ($M_{\rm V} = 3.52$) system. We detect Ca II K emission from both components.

HD 197192: probably variable. There are two similar *RV* values in the SIMBAD database which differ significantly from our determination, and it is reported by CORAVEL as SB; we conclude that this star is indeed an SB2, but not likely to be a very close binary ($M_{\rm Va} = 5.88$, $M_{\rm Vb} = 7.23$). We detect Ca II K emission from the primary component and also a weak secondary emission.

HD 197239: it seems single in our spectra and from our three RV measurements; however, it is reported as a suspected SB by CORAVEL. It was considered as single in the analysis.

HD 199672: the trigonometric distance ($D = 50^{+46}_{-16}$) has a large error, but it is precise enough to ensure that the star is not evolved.

HD 202077 = BM Mic: photometric periods in the range 14.65–15.37 days have been reported by Strassmeier et al. (1997); we detect Ca II K emission; $M_{\rm Va} = 3.10$, $M_{\rm Vb} = 4.20$.

HD 202908: is part of a multiple system; is itself a VB ($\rho = 0\farcs23$), and the A component is an SB2 system ($M_{\rm Va} = 4.41$, $M_{\rm Vb} = 4.62$). Soederhjelm (1999) computed a total mass of 3.07 $M_\odot$ and an orbital period of 79 years; Fekel et al. (1997) presented a detailed study reporting average $v \sin i$ of 11.0, 10.3 and 6.5 km s^{-1} for the Aa, Ab and B components, respectively. The spectral types [(F8V+F8V)+G1.5V] proposed by Fekel et al. (1997) are too early to fit the observed colors which are, instead, well matched by the system proposed by us, whose total mass is also in agreement with the value computed by Soederhjelm (1999) and with the *V*-band magnitude differences (B–A = 1.26, Ab–Aa = 0.21, B–Aa = 0.61) listed by Fekel et al. (1997). Our spectra include both components, and we detect clear Ca II K emission from the B component and possibly from the Aa and Ab components as well.

HD 202917: Soderblom et al. (1998) classified this as a young star ($v \sin i = 12 \pm 4$ km s^{-1}, $A_{\rm Li} = 3.28$) and reported a filled-in Hα line with no convincing evidence for duplicity; HD 202917 is also listed as unsolved variable in the Hipparcos catalogue. Our photometry gives clear indication of optical variability, and we detect Ca II K emission.

HD 202947 = BS Ind: an eclipsing binary for which a period of 0.44 days is reported in the Hipparcos catalogue. The Li line is detectable only in the spectrum of the primary component; we detect Ca II K emission from both components; $M_{\rm Va} = 6.01$, $M_{\rm Vb} = 6.68$.

HD 206488: a triple system; the A ($v \sin i = 20$ km s^{-1}) and B components are about $26\farcs1$ apart, the C component ($V = 14.7$) is about $36\farcs3$ away. Our spectra refer to HD 206488B (=SAO 127004), the photometric data listed in Appendix 1 refer instead to HD 206488A; if the A and B components are physically linked, the cooler B component has to be an evolved star, as confirmed by the strength of the Fe 6710.3 Å line detected by us.

HD 206681: a VB ($\rho = 4\farcs45$). We obtained separate spectra for the two components; the primary star is an SB2 ($M_{\rm Va} = 3.57$, $M_{\rm Vb} = 6.79$) system, and the Li line and Ca II K emission are detectable only for the G2 IV component.

HD 206860 = HN Peg: Gaidos (1998) lists $P = 4.86$ days, $A_{\rm Li} = 3.08$ and $v \sin i = 11$ km s^{-1}; we detect Ca II K emission.

HD 207377: a VB ($\rho = 0\farcs18$) seen as SB2 in our spectra; we detect Ca II K emission from both components.

HD 209234: is listed as unsolved variable in the Hipparcos catalogue; we detect Ca II K emission.

HD 212091: a VB ($\rho = 0\farcs82$) seen as SB3 in our spectra; the primary AB component is a true SB2 ($M_{\rm Va} = 5.25$, $M_{\rm Vb} = 5.62$) for which we detect Ca II K emission from both components. The C component was included in the slit and is detectable in the spectra.

HD 212698 + HD 212697: is the VB 53 Aqr ($\rho = 2\farcs20$); we obtained separate spectra for the two stars. $A_{\rm Li}$ of 2.8 and 2.9 for the two components, respectively, were obtained by Pallavicini et al. (1987); a possible SB1 nature for HD 212697 is obtained by CORAVEL. From our data the companion, if any, should be a very late-type star.

HD 212837: optical variability is possible; we detect Ca II K emission.

HD 214494: a VB ($\rho = 0\farcs54$) seen as SB2 in our spectra; we detect Ca II K emission from the primary component; an orbital period of about 300 years was inferred by Heintz (1997).

HD 215247: we detected Ca II K emission.

HD 215657: probably variable; we detect Ca II K emission.

HD 217343: is listed as unresolved variable in the Hipparcos catalogue; we detect Ca II K variable emission.

HD 217344 = TZ PsA: a VB ($\rho = 3\farcs89$); our spectra refer to the primary component, and we detect Ca II K emission from the G4V/IV star. Osten & Saar (1998) give $P =$ 1.648 days, $v \sin i$ of 35 and 25 km s^{-1} for the two components, respectively, and a G5 V + K3 V classification; the resulting minimum stellar radius is too large for a G5 V star, and the photometric distance ($d_{\rm ph} = 57$ pc) is also below the value measured by Hipparcos ($D = 66^{+8}_{-7}$). A good fit of the distance, radius and observed colors is obtained by assuming a slightly evolved G4 V/IV star ($M_{\rm Va} = 4.50$) and a K3 V star ($M_{\rm Vb} = 6.74$). Favata et al. (1995) report on Li observations, but the very large $v \sin i$ they measured is not confirmed neither by Osten & Saar (1998), nor by us.

HD 218602: the *RV* variability, which is evident in our data, was not detected by CORAVEL; the companion is likely to be a late M-type star not very close. Optical variability is likely; we detect Ca II K emission.

HD 218687: a VB ($\rho = 31\farcs4$); our spectra refer to the primary component for which we detect Ca II K emission. Separate magnitudes and $V - I$ colors ($V = 6.57/10.28$, $V - I = 0.59/1.56$) were obtained by Cuypers & Seggewiss (1999).

HD 221402: listed as an unsolved variable in the Hipparcos catalogue; we detect Ca II K emission.

HD 222259 = DS Tuc: a VB ($\rho = 5\farcs31$); we obtained spectra for both components and detect Ca II K emission for the primary. Cutispoto et al. (1999) inferred a photometric period of 1.54 days, observing both components simultaneously; Soderblom et al. (1998) list a $v \sin i$ of 13 ± 3 km s^{-1}, $A_{\rm Li} = 3.15/1.6$: for the two components, respectively and deduce the SB2 nature of the secondary component. $M_{\rm VBa} = 6.94$ and $M_{\rm VBb} = 7.50$ for the stars of the secondary component.

HD 223537: we detect Ca II K emission from both components; $M_{\rm Va} = 5.07$, $M_{\rm V} = 5.18$.

Appendix 3: Radial Velocity data

Table 5 lists our radial-velocity determinations. We indicate the components of VBs and the components of SBs with capitals and lower case letters, respectively. In the last column we indicate the spectral region from which the RV was computed (see Sect. 3.1 for further details).

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